Modeling Initiation in Exploding Bridgewire Detonators

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There is great interest in the dynamics of exploding bridgewire (EBW) performance and its role in the process of initiation in EBW detonators. In particular, we need to better understand the mechanism by which electrical energy stored in a fireset transforms into initiating energy within a high explosive, and how this mechanism is altered by changing materials and geometry. This project uses LLNL's magnetohydrodynamic (MHD) code CALE to model the explosion of EBWs when placed in a circuit with a fireset.

The models have been generalized from 1-D to 2-D, with the capability of including aging effects, such as the growth of intermetallic compounds.

Project Goals

The deliverables of this project include: sufficiently accurate 2-D models for pure metal EBWs surrounded by high explosive; models that predict performance of aged systems; and experiments to validate the MHD models in CALE at low energies, and the associated analyses needed for model validation. The final product is a simulation capability for EBW and slapper initiation in arbitrary configurations, an assessment tool for detonator reliability.

Relevance to LLNL Mission

This problem is of particular interest because the aging of soldered gold EBW detonators is not sufficiently understood. This simulation capability will enhance LLNL's predictive toolset, which is critical to LLNL's stockpile stewardship mission.

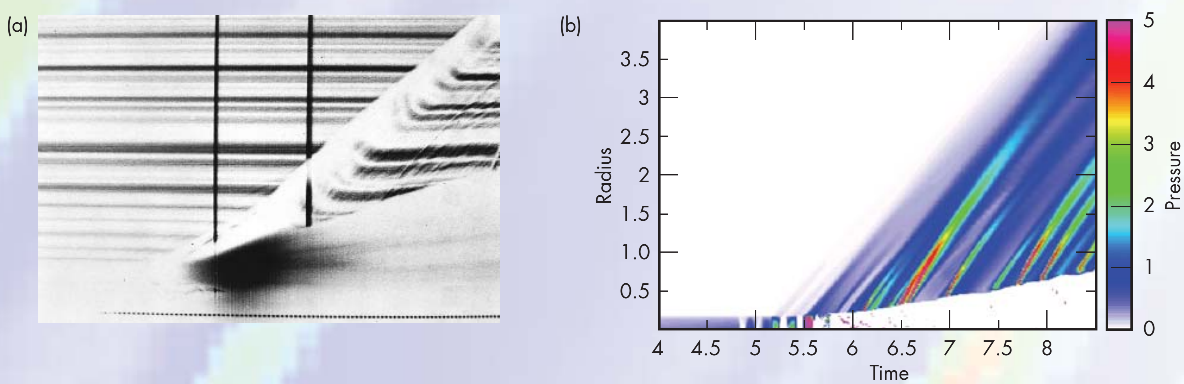

Figure 1. (a) Experimental streak image of a gold wire exploding in water. Time increases to right; the radius increases upward. Note wire expansion, followed by the material expansion (lower sloped curve) and the shock wave sent into the surrounding medium (upper sloped curve). (b) 1-D simulation of the underwater EBW experiment, presented as a streak image. Colors depict pressure levels in the wire and water.

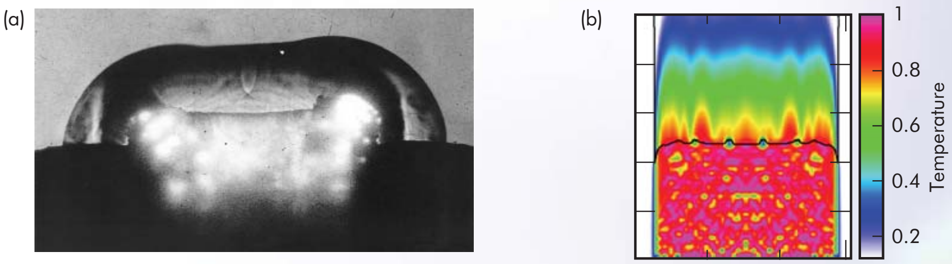

Figure 2. (a) Experimental frame image (side view) of a gold wire luminescing as it explodes. (b) Preliminary 2-D longitudinal simulation of the underwater EBW experiment. Colors show material temperature levels.

FY2004 Accomplishments and Results

One-dimensional models of wire burst were compared with recent and historical closed-form calculations, as well as underwater wire burst experiments and full detonator test fire experiments. The 1-D model predicts most metrics of interest (such as time of burst and burst current) with reasonable accuracy, but is still in need of improvement in predicting EBW pressure output. Figure 1 demonstrates qualitative agreement between experiment and 1-D simulation streak images.

Also, 2-D models were created to better understand both longitudinal and axial aspects of EBW performance. Figure 2 shows comparison between a longitudinal view of an exploding gold bridgewire, and a 2-D CALE simulation. The incorporation of a preliminary material model for gold-indide is a recent accomplishment, due in part to experimental studies completed to find this material's coefficient of thermal expansion. This property is needed for estimation of the Gruneisen gamma, a parameter that influences both shock and MHD aspects of the material's response.

Related References

1. Chace, W. G., and H. K. Moore, Exploding Wires, Plenum Press, Inc., New York, New York, 1959.
2. Maninger, R. C., "Predicting Time-of-Burst of Exploding Bridgewires from Thermodynamic and Electrical Properties," *4th Symposium on Engineering Aspects of Magnetohydrodynamics*, April 1963.

FY2005 Proposed Work

We have plans for model validation through underwater burst experiments on specially made EBWs of various materials. In particular, the material gold-indide requires further experimental study to be successfully integrated into our EBW models. The models will be further generalized to make predictive statements about initiation in PETN, a high explosive commonly used with EBWs, in effect, simulating the crux of detonator function.